1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 714 MARCH 11, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

IMPERIAL BUREAU OF MYCOLOGY 28 JUN. 1921

SWEET-POTATO DISEASES.

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INTRODUCTION.

The sweet potato holds relatively the same relation to the South that the Irish potato does to the North. Practically every farmer grows a few for home use, while some grow them for the market. In addition to many large centers in the South where sweet potatoes form the principal money crop, the industry has been intensively developed in one or two sections in the States of New Jersey, Delaware, Ohio, Illinois, Iowa, and Kansas. The small grower usually sells his surplus stock when it is dug. The big growers, on the other hand, generally store a part or all of their crop, to be placed on the market during the winter, when the prices are high.

The sections devoted to the industry are sufficiently large at the present time to supply the demand if reasonable returns can be expected. If the crop were sold in the fall when prices are low, actual

NOTE.—This bulletin is of interest to growers of sweet potatoes in the Eastern, Southern, Middle Western, and Southwestern States.

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losses would result. Consequently many storage houses have been built throughout the country with the hope that the crop may be kept and put on the market during the winter. In this undertaking some growers have succeeded, while some others have lost a large percentage of the crop from storage rots, consequently realizing less than if the potatoes had been sold in the fall for what they would bring. In some localities the losses sustained in the field together with the subsequent losses in storage have exacted such heavy toll that many farmers are tempted to abandon the industry. It is believed, however, that with a better knowledge of field diseases and storage rot and of the conditions which bring them about, together with an understanding of storage-house manipulation, much of the loss can be prevented.

In general, the purposes of this bulletin are (1) to give a brief discussion of the characteristics of the various diseases in the field and in the storage house and (2) to present methods for the control of these diseases, so far as they are known at the present time.

The sweet potato troubles may be divided into three general classes, as follows:

1. Diseases of the roots and stems (field troubles).
   - Stem-rot (wilt, blue-stem, yellow blight).
   - Black-rot (black-shank, black-root).
   - Foot-rot (die-off).
   - Scurf (soil-stain, rust, Jersey mark).
   - Root-rot.
2. Diseases of the leaf.
   - Leaf-blight.
   - White-rust (leaf mold).
   - Leaf-spot.
3. Storage rots.
   - Soft-rot (collar rot, ring-rot.)
   - Black-rot.
   - Dry-rot.
   - Java black-rot.
   - Charcoal rot.

STEM-ROT (WILT, BLUE-STEM, YELLOW BLIGHT).

DESCRIPTION.

The symptoms of stem-rot caused by the fungi *Fusarium batatatis* and *Fusarium hyperoxysporum* differ somewhat with different varieties. The first indication of the disease in the field is a slight difference in the color of the foliage of affected plants as compared with that of healthy plants. The leaves become duller in color, then yellowed between the veins and somewhat puckered, these symptoms being followed by wilting of the affected vines (fig. 1). The youngest or apical leaves are generally the first to show signs of

disease. If the stem of a diseased plant be pinched open it will be found to be blackened inside. This discoloration sometimes extends 3 to 5 feet from the hill and is a sure sign of stem-rot. Later the stem ruptures and the surface becomes blackened and rotted, though the plant may produce a few potatoes, on which sprouts frequently develop. The organism causing stem-rot may also invade the roots, forming a blackened ring about a quarter of an inch below the surface (fig. 2). If such potatoes are used for seed the sprouts developed therefrom are likely to be diseased.

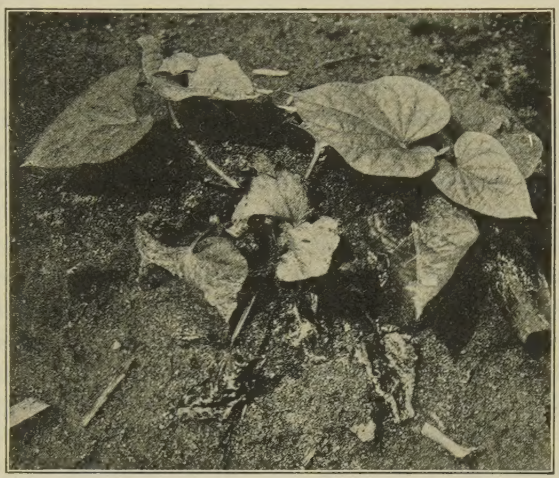

FIG 1.—A sweet-potato plant showing the characteristic symptoms of stem-rot.

In the hotbed the symptoms of the disease are similar to those in the field. Diseased plants can generally be detected by the faint purplish tint which is cast through the white part of the stem and by the yellow discoloration of the leaves.

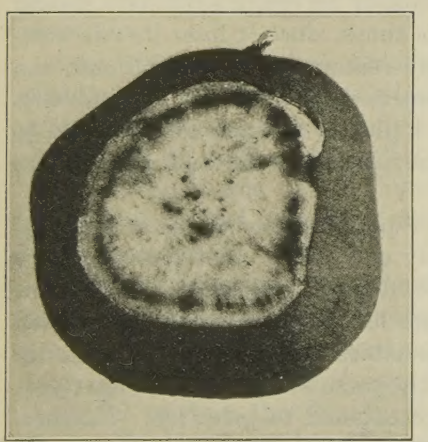

FIG. 2.—Sweet-potato stem-rot. A section through a sweet potato showing the blackened ring just below the surface caused by the stem-rot fungus.

CONTROL.

Fertilizers and fungicides ineffective.—In view of the fact that the fungus causing stem-rot invades the interior of the plants, fungicides can not be expected to give any relief. The application of lime and gypsum to the soil is of no value.

Seed selection.—It has already been pointed out that the fungus invades the roots of the sweet potato and lives over in the potatoes in the storage house; also that the fungus grows from diseased seed potatoes into the plants developed from them. In the early stages

these diseased plants are hard to detect, and, in consequence, many of them are set in the field, where the growth of the fungus continues. It is, therefore, imperative that only healthy potatoes be used for seed. Healthy seed can be secured by selection in the fall at digging time, while the potatoes are still attached to the vines. Each hill should be tested by splitting the stem, and potatoes should be taken for seed only from plants the insides of which are not streaked with black. It should be remembered that a heavy frost will also produce the blackening of the bundles, similar to stem-rot. The fall selection of seed is necessary, owing to the fact that in the spring or during the winter it is difficult and frequently impossible to tell whether the potatoes are diseased or not, since after a period in storage the bundles of healthy potatoes often become somewhat darkened, even though the fungus is not present. The potatoes selected for seed should be stored in baskets in a part of the house where they will not come in contact with the general stock.

In the spring the seed potatoes should be disinfected just before bedding by treating for 5 to 10 minutes in a solution made by dissolving 1 ounce of corrosive sublimate in 8 gallons of water. Only wooden vessels should be used for disinfection. Corrosive sublimate is a strong poison and should be kept out of the reach of animals. After the potatoes are disinfected they should be rinsed in pure water and laid in the sun to dry. This treatment will not kill the stem-rot fungus within the potato, but it will destroy any spores that may be on the surface. The solution of corrosive sublimate should not be used more than two or three times, since it loses its effectiveness after repeated use. If for any reason corrosive sublimate can not be used, the potatoes may be immersed for 5 minutes in a solution of formaldehyde made by adding 1 pint of commercial formalin to 30 gallons of water. They should be rinsed in water and dried before bedding.

Preparation of the hotbed.—The repeated use of the same soil year after year in the hotbed is probably one of the chief sources of the distribution of many sweet-potato diseases. This soil, after the hotbed season is over, is often either left in the beds or thrown out to one side with all the decayed potatoes and manure. The germs contained therein multiply, and if the same soil is used the next year the potatoes and plants are at once exposed to infection. Furthermore, when bedding their potatoes, farmers frequently throw the diseased potatoes out to one side. These eventually become mixed with the soil, and the disease germs are carried on the shoes and by chickens, etc., to the hotbed. As a result of such unsanitary methods hotbeds which might otherwise produce healthy plants become badly infested.

Soil once used in the hotbed should be hauled away, and all the rubbish around the bed raked up and carted off. The framework of the hotbed and the ground around it should be thoroughly soaked with a solution of formaldehyde made by mixing 1 pint of formalin and 30 gallons of water, or, if preferred, with a solution of copper sulphate made by dissolving 1 pound of copper sulphate in 25 gallons of water. It is advisable that this treatment be repeated after about 24 hours. The soil for the hotbed, or preferably sand, should be obtained from some place where sweet potatoes have never been grown, if possible from some high spot in the woods. The upper 6 inches of the soil should be thrown away and only subsoil used. Rich dirt is not necessary for the hotbed; in fact, some of the best results have been obtained by the use of pure sand. The same farm implements used to handle and haul away the old dirt should not be used to handle new soil or sand without being cleaned and disinfected with a solution of either formalin or corrosive sublimate. A grade of subsoil should be used that will not bake or form a crust through which the sprouts can not emerge.

In regions where sweet-potato diseases occur, the use of stable manure in the hotbed is a practice of doubtful value, since potatoes discarded or fed to stock find their way too easily to the manure pile. However, stable manure may be safely used if great care is exercised to cook all decayed or diseased potatoes before feeding them to stock and never to throw them out in the yard, where infected parts may be carried around on the feet of chickens, farm animals, etc.

Crop rotation.—It has already been pointed out that a fair percentage of infection takes place in the field. Although healthy plants may be grown by careful seed selection and care in the preparation of the hotbed, the effort is largely wasted if the plants are set on infected soil. It is, therefore, imperative that the plants be set on new ground or ground which has not produced sweet potatoes for several years.

It is not definitely known how long the stem-rot fungus will live in the soil in the absence of sweet potatoes, but probably for several years. For that reason, sweet potatoes should not be planted on the same ground oftener that once in three or four years. It is very doubtful whether that length of time will completely eradicate the fungus, but it certainly will greatly reduce it. No other crops are known to be attacked by the stem-rot fungus; therefore, any crops commonly grown in the region may be used in the rotation.

Slip seeding.—By slip seeding is understood the practice of cutting up the vines so as to include at least two buds or leaves and sticking one end, usually the larger, into the ground, the potatoes produced therefrom to be used for seed for the next year's crop. Slip

seeding is a practice generally followed in some localities and not at all in others. When intelligently done it is an efficacious means of controlling sweet-potato diseases. However, if practiced independently of all sanitary measures it is of little value. The writer has examined quantities of slip-seed stock, both in the field and in storage, and found an abundance of stem-rot, black-rot, foot-rot, and practically all of the diseases present in that particular locality. In regions where the disease germs are not present in all soils beneficial results have been obtained.

To obtain results from slip seeding the following precautions must be taken:

(1) The cutting should be made from healthy vines. This will seem obvious when it is remembered that the organism causing stem-rot often grows out into the vines 4 to 5 feet from the hill and it can not always be detected without pinching open the vine.

(2) The cuttings must be planted on new ground or on ground on which sweet potatoes have not been grown for at least six years.

(3) The potatoes produced by the cuttings must be picked over and disinfected in the spring before bedding, according to directions already given.

(4) The seed potatoes must be bedded in a hotbed prepared according to the directions given above.

DISTRIBUTION, PREVALENCE, AND LOSS.

Stem-rot is known to be prevalent in the States of New Jersey, Delaware, Maryland, Virginia, Illinois, Iowa, Kansas, Alabama, and Arkansas and to be present in Missouri, North Carolina, Ohio, Georgia, Texas, Oklahoma, and Mississippi. It is likely that the disease occurs in other States also. In some States the disease is at present relatively unimportant, owing to the fact that varieties have been grown which are somewhat resistant to it or to the fact that the sweet-potato industry is comparatively new and the disease has not yet become serious.

The losses sustained from stem-rot can only be estimated, but in New Jersey alone 10 to 50 per cent of the crop is destroyed each year, and fields have been found where 95 per cent of the plants were killed. In States like New Jersey and Delaware, where the sweet potato forms an important money crop, the losses annually amount to many thousands of dollars. Conditions are equally bad in Iowa, parts of Kansas, and in southern Illinois. In Maryland, Virginia, and Alabama, although the losses are considerable each year, they are relatively less than in New Jersey, Delaware, Iowa, and Kansas. In other States where the disease occurs the losses at the present time are comparatively small. At the most conservative estimate, stem-rot is responsible for a loss of at least three-quarters of a million dollars annually to the sweet-potato crop in the United States.

HOW STEM-ROT IS DISTRIBUTED.

Stem-rot must be considered from the standpoints of its distribution (1) from one field to another and (2) from one locality or State to another. It must be kept in mind that this fungus will live throughout the winter in the soil on the remains of dead sweet-potato vines and in the potatoes in storage. Therefore, the distribution of the disease from one field to another may be brought about by such agencies as (1) insects, (2) farm animals which are allowed to roam from one field to another, (3) farm implements, (4) drainage water, (5) wind, and (6) by the dumping of discarded diseased roots on the fields as fertilizer, either before or after feeding to stock.

The distribution of the disease over wide areas is brought about primarily by the exchange or sale of seed potatoes and plants; in fact, many growers in Illinois, Iowa, and Kansas claim that the disease was not known to them until they imported seed potatoes from Eastern States. Furthermore, some farmers grow plants for sale and send them long distances to other States. In some cases the appearance of the disease in a locality can be definitely traced to the importation of seed potatoes and plants.

It might be advisable as a means of protecting both the plant growers and the farmers buying plants if a system of inspection and certification of establishments by the State pathologist or other duly authorized persons was practiced. Such a system would, it is believed, restrict the spread of some of the worst diseases and protect the growers against loss. The plant-growing establishments would find it imperative to rid their stock of the various diseases, and in the end would be able to place on the market perfectly healthy plants, thereby being protected against claim from the growers for the sale of diseased plants.

CAUSE OF STEM-ROT.

Two different fungi, or moldlike plant growths, cause the stem-rot of sweet potatoes. They are *Fusarium batatatis* and *Fusarium hyperoxysporum*. These two fungi are closely related to other organisms causing similar diseases, such as the wilt of cotton, cowpeas, watermelons, tomatoes, and Irish potatoes. The organisms causing stem-rot of the sweet potato, however, will not under natural conditions attack any other plants. Neither will other organisms causing similar diseases in other plants attack the sweet potato.

So far as known, stem-rot originated in the United States; at any rate it has never been reported from other countries. It was first reported from New Jersey in 1890. According to the testimony of many old growers it was known many years before that, but had not

attained economic importance. These organisms, like many others of their kind, can live for several years on decayed vegetation in the soil until they again come in contact with the sweet potato.

Infection undoubtedly takes place through the roots, either in the field after the plants are set out or in the hotbed by growing from diseased potatoes into the plants. Such infected plants when set in the field soon die.

The mycelium or vegetative part of the fungus develops rapidly and often enters the root and grows up into the water-carrying vessels of the stem, where it forms a barrier to the passing of water and plant food from the roots to the leaves. Following the death of the plant the vines turn black, the fungus living thereafter on the decaying vegetation. On the dead vines numerous fruiting bodies, or spores, are developed. The spores are somewhat curved and several celled, as shown by figure 3. Being very small, they are readily carried by the wind, insects, and other agencies to other fields, where new infections may arise.

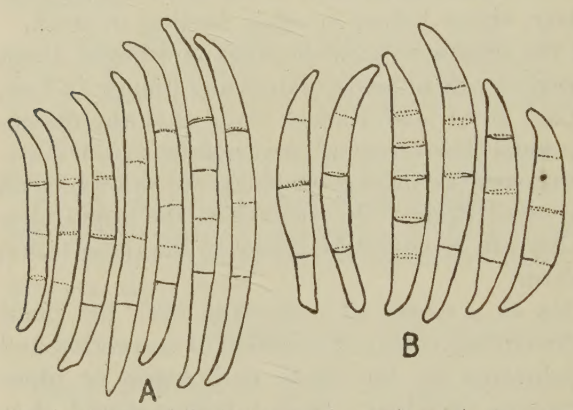

FIG. 3.—Spores of the two stem-rot organisms: *A, Fusarium batatatis; B, Fusarium hyperoxysporum.* × 500.

BLACK-ROT (BLACK-SHANK, BLACK-ROOT).

DESCRIPTION.

Black-rot, caused by the fungus *Sphaeronema fimbriatum*, may occur on any of the underground parts of the plant. On the potato it is characterized by the dark to nearly black, somewhat sunken, more or less circular spots on the surface (fig. 4). In the early stages these spots are small and nearly round, but under favorable conditions they enlarge, until frequently nearly the whole potato is involved. Often in the center of the spots will be seen more or less circular areas, from one-fourth to one-half inch in diameter, in which may be found fruiting bodies of the fungus causing the disease. The surface of the diseased spots has a somewhat metallic luster and the tissue just beneath is greenish.

On the plants the infection begins as small black spots, which gradually enlarge until the whole of the stem is rotted off. Fre-

quently it extends up the stem to the surface of the soil (fig. 5). It is important to remember that if black-rot potatoes are used for seed

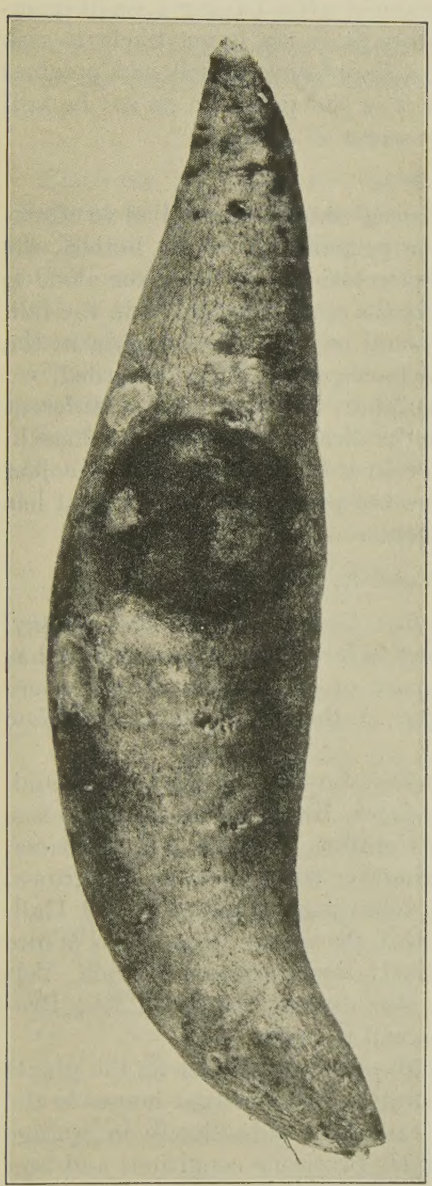

FIG. 4.—Sweet-potato black-rot. A sweet potato showing the black circular spot produced by the black-rot fungus.

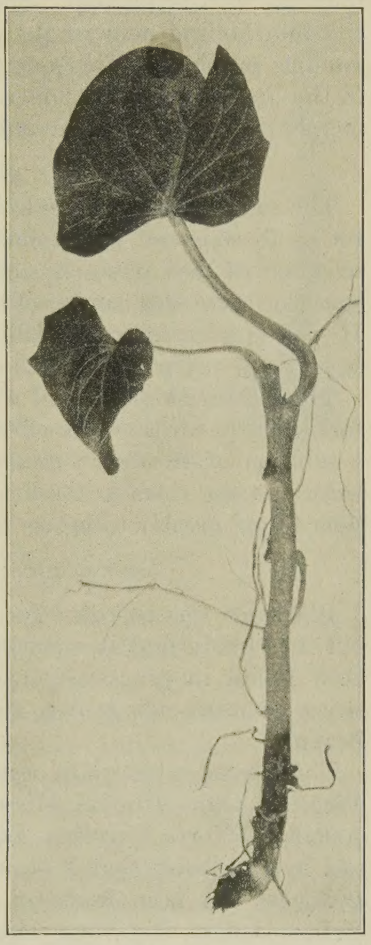

FIG. 5.—Sweet-potato black-rot. Small sweet-potato plant, showing the characteristic blackening of the underground part of the stem.

the plants coming from them will be likely to have black-rot.

All sweet-potato growers are well aware that when cooked, black-rot sweet potatoes have a very disagreeable taste. Therefore, farmers should be very careful not to sell such potatoes (1) because their sale has a bad effect upon the market and (2) because it may be

the means of carrying the disease into an uninfected locality. Many more sweet potatoes would be consumed in the cities if fewer bad potatoes were being sold. The consumer after buying a small quantity and finding none of the potatoes fit to use is not likely to risk another purchase. There may be a temptation to sell bad potatoes to the unsuspecting consumer, but it is bad policy to do so; he will merely retaliate by not buying any more.

CONTROL.

The same control methods in general should be applied to black-rot as to stem-rot, particularly the preparation of the hotbed, the selection of seed potatoes, and crop rotation. If black-rot alone is concerned, the seed can be selected in the spring instead of in the fall. If seed is selected in the fall it should be picked over again in the spring and any potatoes with suspicious spots on them discarded.

The treatment of the soil with sulphur, lime, gypsum, or different fertilizers has little or no effect on the disease. Dipping the slips in a solution of Bordeaux mixture or in a lime-sulphur mixture just before setting them in the field does not prevent the disease, but has been found greatly to injure the plants.

DISTRIBUTION, PREVALENCE, AND LOSS.

Black-rot was reported for the first time in 1890 in New Jersey, but it is likely that it occurred long before that. Since then it has been found in practically every part of the United States where sweet potatoes are grown and also in the West Indies and New Zealand.

The disease is known to occur in New Jersey, Delaware, Maryland, Virginia, Ohio, Illinois. Missouri, Iowa, Kansas, Oklahoma, Texas, Arkansas, North Carolina, South Carolina, Georgia, and Alabama, and it is probable that it occurs wherever sweet potatoes are grown. Black-rot has been found on the following varieties: Nancy Hall, Yellow Jersey, Big-Stem Jersey, Red Bermuda, Miles Yam, White Yam, Southern Queen, Pierson, Early Red Carolina, Florida, Yellow Strassburg, Key West Yam, Red Jersey, Dahomey, Red Brazilian, Yellow Yam, Vineless Yam, and Georgia.

In all the regions mentioned the disease is prevalent on the plants or slips in the hotbed and on the potatoes in the storage houses in the winter; in fact, heavy losses are caused by this disease in storage houses, where it develops freely under favorable conditions and renders the potatoes unfit for consumption.

HOW BLACK-ROT IS DISSEMINATED.

In general, black-rot is disseminated in about the same way as stem-rot. Unlike stem-rot, however, black-rot spreads freely through the storage house under favorable conditions. Small flies and other

insects carry the spores on their bodies from diseased to healthy potatoes, where, if conditions are favorable, a new infection takes place. Distribution in the storage house may also be brought about by the handling of potatoes when they are picked over and prepared for the market or by settling in the bins.

FIG. 6.—Sweet-potato black-rot. A pycnidium of the black-rot fungus in which are contained innumerable hyaline spores.

CAUSE OF BLACK-ROT.

Black-rot is caused by the fungus *Sphaeronema fimbriatum*. It is a disease of the underground parts of the plant. Infection takes place through the roots, either coming from the soil after they are set in the field or by growing on the plants in the hotbed from diseased potatoes used for seed. Plants diseased so early in their life soon die, rarely producing any potatoes. This fungus, like many others of its kind, lives from one year to another on the dead vines or other decayed vegetable matter in the soil until it comes in contact with a sweet-potato plant.

FIG. 7.—Sweet-potato black-rot. A chain of colorless bodies which break apart and serve to reproduce the fungus.

The reproduction and spread of the black-rot fungus is provided for by three different types of spores borne in the black, decayed portion of the young plant below the soil and in the roundish, sunken, dead spots on the potatoes. One type of spore is colorless and round and is borne in great numbers inside a minute flask-shaped receptacle called the pycnidium, with a long, thin neck, as shown by figure 6. These spores pass out through the neck of the pycnidia and accumulate on the end in the form of a whitish viscid mass, and are carried by insects and other agencies to various places, where new infections may start. Buried in the dead tissue of the host are found brown spherical bodies with thick walls, which may serve to carry the disease from one season to the next. The mycelium is branched and mostly colorless, but differs from that of many other fungi in that it may break up into a large number of parts, each of which functions as a spore. These parts are colorless, cylindrical, and slightly rounded at the end, averaging about four times as long as broad (fig. 7).

FOOT-ROT (DIE-OFF).

DESCRIPTION.

Foot-rot appears first as small brown to black spots on the stem of the plant near the soil line. Its growth at first is very slow, but

eventually it girdles the plant and extends up the stem 4 or 5 inches. Soon thereafter wilting of the plant begins, and round, black, rather numerous specks, just visible to the naked eye, appear in the diseased areas (fig. 8). These specks are the fruiting bodies of the fungus causing the disease. Owing to the fact that this disease progresses rather slowly, it is about midsummer or later before the plants begin to die off. In most instances no potatoes are found in the affected hills, though long vines may have been produced.

FIG. 8.—Sweet-potato foot-rot. The lower part of a sweet-potato plant killed by the foot-rot fungus. Note the fruiting bodies embedded in the diseased tissue.

The organism causing foot-rot may grow from an infected stem on to the roots and cause a brown, rather firm rot of the potato. Later, fruiting bodies standing close together develop on the surface in the form of pimple-like protuberances (fig. 9). Many wounds and bruises on potatoes in storage are infected with the foot-rot fungus.

CONTROL.

The same control measures should be employed for this disease as for stem-rot and black-rot—namely, seed selection, the use of clean seed beds, and crop rotation.

DISTRIBUTION, PREVALENCE, AND LOSS.

Foot-rot is distributed in the same way as stem-rot and black-rot, through diseased soil, exchange of plants or seed potatoes, etc.

Foot-rot is known to occur in Virginia, Ohio, Iowa, and Missouri, and it is likely that it occurs elsewhere.

Owing to the fact that it is not so widely distributed, the total loss that may be attributed to this disease is much less than that

due to black-rot and stem-rot. In localities where it does occur, however, it produces greater loss than either of those diseases. In certain sections of Virginia, Ohio, and Iowa it has been estimated to produce a loss of 50 per cent of the crop in one year.

FIG. 9.—Sweet-potato foot-rot. A sweet potato rotted by the foot-rot fungus. Note the fruiting bodies crowded together over the surface.

CAUSE OF FOOT-ROT.

To the fungus causing foot-rot the name *Plenodomus destruens* has been given. This organism is similar to a large group of fungi causing diseases in other plants, as, for example, some of the leaf-spots. It does not, however, attack any plants other than sweet potatoes so far as known.

Foot-rot was first discovered in 1912 in Virginia. There is no doubt that it existed some years previous to that time. It is often confused with black-rot and stem-rot by farmers and probably for that reason it was not recognized earlier as a distinct disease.

Infection takes place primarily through the roots or underground parts of the plant, though during wet periods, when the growth is very luxuriant, diseased vines are sometimes found some distances from the hill. Like stem-rot and black-rot, infection takes place either in the field after the plants have been set out or in the hot-bed by growing from diseased potatoes on to the plants. Such plants, when set in the field, usually die early in the season, or at any rate seldom produce any potatoes. The growth of the fungus is very slow at first and it is usually midsummer before field infections produce any marked injury. The organism advances along the stem to 4 or 5 inches above the soil line, turning the surface brown. About this time the vine wilts and the plant dies. In the diseased tissue pimply, domelike projections, the pycnidia, just visible to the naked eye, can be seen scattered over the surface. The spores, (fig. 10, *A*), borne in great numbers, escape from the pycnidia (fig.

10, *B*) and are carried by insects or other agencies to other plants, where new infections may result. The fungus may live as a saprophyte for several years on the dead vines or other decayed vegetable matter.

It is important to remember that this fungus can carry on a saprophytic existence where the host is not present. This enables it to remain much longer in the soil than would otherwise be the case. If a diseased plant produces potatoes the fungus often grows down the roots and infects the potatoes. Here it may remain dormant during the storage period, but will develop in the hotbed and infect the plants produced. Like stem-rot and black-rot, there-

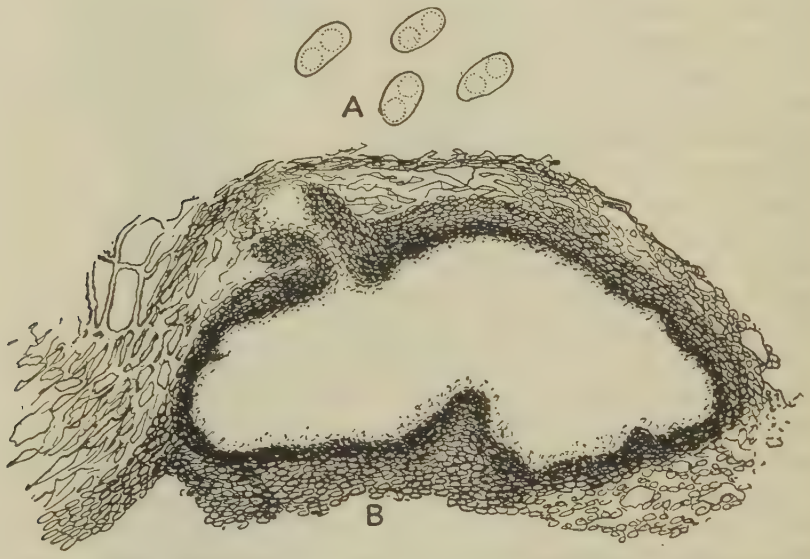

FIG. 10.—Sweet-potato foot-rot: *A*, Spores of the foot-rot fungus; *B*, a fruiting body in which the spores are borne.

fore, diseased seed potatoes give diseased plants, which in turn may produce diseased potatoes in the field. By this means the disease may be carried along with the crop indefinitely.

SCURF (SOIL-STAIN, RUST, JERSEY MARK).

DESCRIPTION.

Scurf is characterized by a brown discoloration of the surface of the underground parts of the sweet-potato plant (fig. 11). The discolored areas may take the form of spots of varying sizes and shapes with no definite outline or there may be a uniform rusting of the entire surface of the potato. The scurf produces no rupture of the sweet potato and is so superficial as to be easily scraped off by the finger nail.

CONTROL.

To control this disease the seed potatoes should be disinfected for 10 minutes in a solution made by dissolving 1 ounce of mercuric chlorid in 8 gallons of water. They should then be dipped in water and dried. Soil or sand obtained from the woods or from fields where sweet potatoes have never been grown should be used in the hotbed. The plants should be set in new ground or ground never before used for sweet potatoes.

Scurf is worse on heavy soils and on soils containing a large quantity of organic matter, such as manure. Such soils should be avoided. It is likewise worse during a wet season and on low wet ground. The treatment of the soil with fungicides or fertilizers has not been found effective as a means of control.

FIG. 11.—Sweet-potato scurf. A sweet potato, showing discoloration caused by the scurf fungus.

DISTRIBUTION, PREVALENCE, AND LOSS.

Scurf is very common, having been found in Arkansas, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Ohio, Illinois, Iowa, Texas, and Kansas, and on practically all varieties.

The loss to the crop caused by scurf is perhaps small in comparison with some of the other more serious diseases; nevertheless, the actual financial loss throughout the country that can be attributed to this disease alone amounts to considerable. Scurfy potatoes do not command as high a price in the market as clean ones, though if otherwise sound they are just as good for food. The scurf under favorable conditions, such as a relatively high humidity and temperature, continues to develop under storage conditions to a limited degree. It weakens the

host, so that during periods when the storage house is rather dry the potato loses moisture and becomes shriveled and dried.

CAUSE OF SCURF.

Scurf is caused by the fungus *Monilochaetes infuscans*. The causal organism is a brown, unbranched fungus, bearing a colorless spore at the end (fig. 12). The mycelia and spores live through the winter on the potatoes in storage and on the decayed vines in the field. So far as known the fungus does not attack any other host. If infected potatoes are used for seed, the fungus grows on to the plants and is carried by them to the field. The organism produces no apparent injury to the plants in the hotbed or in the field, but it continues its growth and follows down the roots to the potatoes. The spores may be produced at any time, provided there is a high percentage of moisture present and the temperature is high enough for their growth, that is, about 50° to 85° F. It is likely, however, that the disease can be propagated by the threads, or hyphæ, which are produced in considerable numbers. The organism causing scurf will grow for a considerable time as a saprophyte in the absence of the sweet potato. Wet soils and soil containing a large quantity of organic matter are favorable to the disease. This fact has been recognized by many growers, and the disease is thought by them to be a stain caused by manure or organic matter.

FIG. 12.—Sweet-potato scurf. A sporophore bearing a hyaline conidium of the scurf fungus. These bodies occur only on the surface of the underground parts of the plant.

ROOT-ROT.

DESCRIPTION.

This disease is best known as the Texas root-rot of cotton and alfalfa. The causal organism gains access to the plants on the underground parts and spreads in both directions, invading the vines for 6 to 12 inches above the ground. It may enter the potato at the end or form lesions of varying sizes on the surface. In either case a firm brown rot is produced, resulting in the complete destruction of the potato (fig. 13). Above ground the growth is within the stem and may be detected by the brown discoloration produced. The organism lives from one season to the next in the soil on dead vegetable matter, or in the far South probably on growing winter crops. It is killed by hard freezing, and this alone probably restricts the fungus to the Southern States.

CONTROL.

Root-rot is worse on black, poorly drained soil and during wet seasons. The disease is particularly difficult to control or eradicate because it has such a great variety of hosts. Deep, clean cultivation, aeration of the soil, and crop rotation are important in controlling the disease in cotton. The same methods, together with the careful selection of disease-free potatoes for seed, should be employed for sweet potatoes. The fungus attacks a great variety of plants, both wild and cultivated. It has not been known, however, to injure corn or any of the cereals, so these crops should be used in the rotation.

FIG. 13.—Root-rot. A sweet potato showing the characteristic shriveling produced by the root-rot fungus.

DISTRIBUTION, PREVALENCE, AND LOSS.

Root-rot, so far as known, occurs only in Texas, New Mexico, Oklahoma, and Arizona. When the disease once gets into a field a whole crop may be destroyed. Large fields have been seen in which not more than 10 per cent of a crop was produced. Viewed from a distance, the field looked promising, but when harvested the potatoes were nearly all found to be destroyed by the fungus.

The disease may occasionally be observed as early as May or June, but it is in August that it becomes really serious. By this time the vines are well developed and the potatoes of considerable size. The disease from this time increases in severity, so that by September and October, when the potatoes are dug, it has practically destroyed a large percentage of the crop. It may occur in localized spots. Not all hills and not all the potatoes in a hill are completely destroyed, though fields have been examined where 90 per cent of the crop was lost.

CAUSE OF ROOT-ROT.

Root-rot is caused by the fungus *Ozonium omnivorum*. No spore stage of this organism is known, and it presumably lives from one

season to the next by means of the hyphæ, which are brown, septate, and branched, the branching being nearly at right angles. The mycelia, or hyphæ, are produced on the surface in the form of grayish wefts or strands, which can be easily recognized with a hand lens by one familiar with the disease. Under the microscope the strands are seen to be composed of interwoven hyphæ of the root-rot fungus.

LEAF-BLIGHT.

Leaf-blight is caused by a fungus known as *Phyllosticta batatas*. It appears on the upper side of the leaf as roundish or angular spots, one-eighth to one-half an inch in diameter (fig. 14) and separated from the healthy tissue by a dark line. Inside this line is a strip of brownish tissue which has lost most of the green color. Still inside this ring is a circular area, much lighter in color, in which a number of black bodies are found. These black bodies, the pycnidia, about the size of a pin point and just visible to the naked eye, may take a more or less circular arrangement, or they may be scattered indiscriminately within the spot. The pycnidia are slightly raised and rounded in a domelike manner and contain numerous colorless spores. So far as is known the fungus is not parasitic on any other plant; neither does it occur on other parts of the plant than the leaf. It is thought to live through the winter on the dead leaves. The disease occurs every year in the Southern States and attacks primarily the mature leaves.

FIG. 14.—A leaf of a sweet-potato plant, showing the presence of a number of circular leaf-blight spots. Note the numerous black specks, within the spots, in which the spores are borne.

Leaf-blight occurs practically everywhere in the Southern States, but is less common as far north as New Jersey, Delaware, Maryland, Iowa, Kansas, and Illinois. The Phyllosticta leaf-blight has never been serious enough to require remedial measures.

LEAF-SPOT.

Leaf-spot, caused by *Septoria bataticola*, similar in general appearance to leaf-blight, occurs on sweet potatoes. The spots, one-fourth to one-eighth of an inch in diameter, are scattered indiscriminately over the foliage (fig. 15). They are white, surrounded with a brown border. Within these white areas one or more black specks, the pycnidia, just visible to the naked eye, may be found. In the pycnidia are contained numerous spores, which upon escaping from the pycnidium are carried by insects or other agencies to other leaves, where a new infection may start. Like the organism causing leaf-blight, this fungus is not known to be parasitic on other plants or other parts of the sweet potato. It probably winters over on the dead leaves in the field.

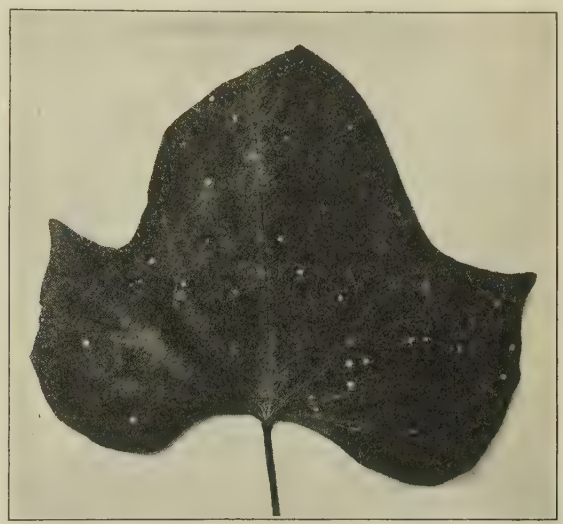

FIG. 15.—Leaf-spot. A leaf of a sweet-potato plant showing white spots caused by the leaf-spot fungus.

Leaf-spot is very widely distributed, having been collected in New Jersey, Delaware, Iowa, and other States where sweet potatoes are grown. This disease is nowhere serious enough to require remedial measures.

WHITE-RUST (LEAF MOLD).

The first symptom of white-rust is a loss of the green color in indefinite spots on the under side of the leaf (fig. 16). Later, these spots become brown and covered with a whitish, viscid growth, which is finally more or less powdery. This white powdery mass is made up of numerous spores or reproductive bodies, which serve to start a new infection if they fall on another leaf and conditions are favorable, such as a high temperature and a relatively high humidity. Frequent rains and heavy dews are favorable to the spread of this disease. No great amount of harm results from the attack of this fungus, though it may sometimes produce swellings on the stems and petioles and malformations of the leaves. White-rust is widely

distributed and occurs on a number of other plants, among them the wild morning-glories. This disease has never been serious enough to require remedial measures.

White-rust is caused by a fungus known as *Albugo ipomoeae-panduranae*. It is more prevalent during wet seasons. It has been found in New Jersey, Iowa, Virginia, and Maryland, and probably occurs in many other States.

STORAGE ROTS.

SOFT-ROT.

Soft-rot, due to a mold known as *Rhizopus nigricans*, is one of the most destructive diseases in the storage house. The decay begins at one end of the potato and continues its growth rapidly, requiring but a few days in the presence of high temperatures and a relative high humidity to destroy the entire potato. Usually soft-rot sets in soon after the potatoes are stored and continues more or less throughout the storage period, depending largely upon the management of the house. The potatoes are first rendered soft, watery, and stringy. After decay and following the escape of moisture the potatoes become gradually firm, hard, and brittle. Such dry potatoes are frequently referred to by the farmer as being affected with a dry rot, while in reality it is a dried soft rot. If the skin is ruptured while it is still soft, the causal organisms form a moldy growth on the surface (fig. 17). One soft-rot potato may be the means of communicating the disease to numerous potatoes lying close to it. The spores of the black mold produced on the surface may be carried by flies or communicated to other potatoes by handling in the same house, where new infections may take place if the temperatures are sufficiently high and an abundance of moisture is present.

FIG. 16.—White-rust. A leaf of a sweet-potato plant, showing the white-rust fungus.

RING-ROT (COLLAR ROT).

Ring-rot is caused by the same mold (*Rhizopus nigricans*) as soft-rot. It differs from soft-rot in that the decay begins at a point between the two ends instead of at the ends. From the point of infection the decay forms a ring or collar around the potato, while at the same time it extends slowly toward the two ends. Under favorable conditions the potato may be wholly destroyed. If, on the other hand, conditions unfavorable for its further development exist, such as a relatively low humidity and low temperatures, it may develop no further than to form around the potato a ring or collar (fig. 18), varying in width from 1 inch to 2 or 3 inches.

FIG. 17.—Soft-rot. A sweet potato showing the moldy growth of the fungus causing soft-rot.

The losses sustained in storage from soft-rot and ring-rot amount to many hundreds of thousands of dollars annually. The fungus causing soft-rot is the common bread mold. It is found everywhere and will grow on almost any decaying vegetable matter. It is, therefore, impossible to exclude it from storage houses. It is a mold, however, which generally gains an entrance through wounds and bruises made on the potato by rough handling. In the presence of an abundance of moisture and high temperatures, the fungus growing in the wounds destroys the potato.

BLACK-ROT.

Black-rot, caused by *Sphaeronema fimbriatum*, although a serious disease of the plants in the hotbed and in the field, as has already been shown, is a storage rot as well. The loss throughout the country caused by it in storage and in the field probably equals that of all the other diseases combined. When sweet potatoes are dug, black-rot spots are comparatively rare, but it is likely that many potatoes are infected, the point of infection being so small as to be invisible to the naked eye. In the storage house, in the presence of comparatively high temperatures and a relatively high humidity, these spots gradually enlarge, and at the end of a month or two they have formed conspicuous, somewhat round sunken spots on the surface of the potato (see fig. 4). Near the center of these spots are numerous flask-shaped fruiting bodies, from which exude myriads of small spores. These readily adhere to the bodies of insects and are carried to other potatoes, where infection takes place if sufficient moisture is present. The germs may also be scattered about by workmen preparing potatoes for the market.

FIG. 18.—Ring-rot. A sweet potato showing ring-rot, frequently found in storage houses.

DRY-ROT.

This is another form of rot which generally begins at the end of the potato, producing a firm brown rot. It grows slowly, the potato finally becoming dry, hard, and mummified (fig. 19). Small domelike or pimplelike protuberances just visible to the naked eye finally cover the entire surface. If the epidermis is scraped slightly, the tissue beneath presents a coal-black, carbonaceous appearance. Several weeks are required under normal conditions for this organism to completely destroy a potato.

Dry-rot is caused by a fungus known as *Diaporthe batatatis*. In the little domelike protuberances (fig. 19) on the surface are to be found myriads of colorless spores, which serve to reproduce the fun-

gus. The dry-rot fungus grows on the stems and vines above ground under field conditions, and it is here probably that potatoes become infected. It has on many occasions been found on the stems of young plants in hotbeds.

Dry-rot is widely distributed throughout the country and is frequently met with, but it can in no sense be regarded as one of the more serious storage troubles.

FIG. 19.—Dry-rot. A sweet potato showing the characteristic appearance of dry-rot.

FIG. 20. — Java black-rot. A sweet potato showing the dry, mummied condition produced by the fungus. Note the numerous pimplelike protuberances containing spores borne on the surface.

JAVA BLACK-ROT.

Java black-rot, so called because its discovery on potatoes grown from an importation from Java suggested that the disease might have been introduced from that country, is widely distributed in storage houses, but is more prevalent in the South.

The disease is caused by the fungus *Diplodia tubericola* and is strictly a storage trouble. It slowly renders the potatoes dry, hard,

brittle, coal black within, and difficult to break (fig. 20). It is reproduced by brown 2-celled spores (fig. 21), borne in more or less flasked-shaped receptacles beneath the surface. When the surface of the potato is ruptured, these spore bodies are set free. The spores are at first colorless and one celled. The Java black-rot begins usually at the end and grows very slowly, requiring under normal storage conditions from 4 to 8 weeks to completely destroy a potato.

CHARCOAL ROT.

A rot of less economic importance is occasionally found in the storage houses throughout the country, which likewise produces a black decay. This form of rot differs from others of a similar appearance by the production by the fungus of minute spherical resting bodies throughout the potato, rarely on the surface. These bodies are coal black and stand mostly separated from each other. If the surface of the potato be carefully opened, these bodies can be seen by the naked eye buried in the tissue. Some shrinking and drying of the potato follow an invasion of this fungus. The total loss to the crop that might be attributed to this disease is comparatively small. It is caused by the fungus *Sclerotium bataticola.*

FIG. 21.—The dark 2-celled spores of the Java black-rot fungus.

CONTROL OF STORAGE ROTS.

The United States could and would produce many more sweet potatoes if they could be marketed at a fair profit. One of the chief barriers to the extension of the industry is the inability of the farmers to keep the potatoes in storage so that they can be placed on the market in the winter, when prices are good. As a result most of the potatoes in the South are consumed locally and placed on the market at digging time, when prices are low. Consequently, few sweet potatoes go on the northern markets in the winter, and even in the South where they are grown they can not be obtained with any degree of certainty at that season of the year. It is believed that if storage methods and principles were better understood, more potatoes would be available for winter use and disposed of at a good price.

The success of the industry, however, does not depend on successful storage methods alone. It is a well-known fact that there are several serious field diseases of the sweet potato, the best known of which are black-rot, stem-rot, and foot-rot. The storage of black-rot potatoes must necessarily result in heavy loss, since the disease spreads rapidly throughout the bins. Stem-rot, on the other hand, does not produce any marked decay in storage, but it may open the way for storage-rot organisms to enter the potato. It therefore becomes imperative that

the elimination of the field diseases must be coupled with a well-regulated system of storage.

Great care should be exercised in handling sweet potatoes not to bruise them any more than necessary. The bruises made by rough handling open the way for storage-rot organisms to enter. A farmer would never think of handling apples, oranges, or any of the fruits in the way that sweet potatoes are handled, and yet a barrel of good sweet potatoes will bring as much on the market, and often more, than a barrel of good apples, and sweet potatoes bruise even more readily than apples. It is likely that if sweet potatoes were handled with the same care and intelligence as apples little difficulty would be experienced in keeping them in storage.

After the potatoes are well dried in the field they should be carefully laid in an open crate holding about a bushel and hauled to the storage house. They should not be poured out of this crate into a bin, but stored in the crate itself. The use of crates permits the free circulation of air among the potatoes, a condition which can not be obtained if they are piled in a bin. The crate has an added advantage in that as many potatoes can be taken out for the market during the winter as are desired without disturbing the remainder. Sweet potatoes will not stand frequent handling, and for that reason it is unwise to disturb a pile or bin unless they are all marketed at the same time. The use of crates would eliminate this danger.

DIGGING AND HANDLING.

Potatoes intended for storage should be dug as late in the fall as is consistent with weather conditions. This is usually just preceding frost. Frozen potatoes will not keep well, and it is likely that a heavy frost will injure them to some extent. It is advisable, too, after a heavy frost to cut the vines at once and dig. It is believed that warm, dry, sunny weather preceding a frost is better for all concerned than a period a little later in the season following a frost. To wait too long may mean that in order to avoid freezes the potatoes must be dug during bad weather. After digging, the potatoes should be allowed to dry as long in the sun as is consistent with weather conditions and farm operations. On a very hot day, however, it would be desirable to hurry the potatoes to the shade after their surfaces have been dried in the sun.

THE STORAGE HOUSE AND ITS MANAGEMENT.

While sweet potatoes sometimes keep well when stored in banks with hay and dirt thrown over them, this system is not as reliable as a storage house. For full details on storing and marketing sweet potatoes, the reader is referred to Farmers' Bulletin 548 of the

United States Department of Agriculture. During the digging period and for 10 days or two weeks thereafter, the temperature of the house should be maintained at about 80° to 85° F. This will assist in curing the potatoes and driving off surplus moisture. Ventilators should be so arranged and manipulated that the moisture given off by the potatoes will be carried out of the house. At the end of about two weeks at a temperature of 80° to 85° F. the temperature should be gradually lowered to about 50° to 55° F., and maintained there through the storage period. During the winter the house should be watched as regards temperature and moisture. If there is any moisture accumulating, it should be gotten rid of by opening the ventilators at the top and admitting dry air from below. This should be done on a dry day when the outside temperature is about the same as that of the storage house. It must not be forgotten that the essentials in the management of the storage house are to keep it dry and maintain the temperature as near 50° to 55° F. as possible.

In the fall, just before the sweet potatoes are put in storage, the storage house or cellar should be thoroughly disinfected, in order to get rid of the numerous storage-rot germs left there from the previous crop. There are several efficacious methods that may be employed. The house may be sprayed with a solution made by dissolving 1 pound of copper sulphate in 25 gallons of water or with a solution of formaldehyde made by mixing 1 pint of formalin (40 per cent) in 30 gallons of water. In about 24 hours the house should be sprayed a second time. Similar results may be obtained by whitewashing the storage house or cellar, or, better yet, by making up a barrel of winter strength lime-sulphur solution, 15 pounds of sulphur, boiled until dissolved with 7½ pounds of stone lime, and then the whitewash added to the mixture. A second coat of whitewash will not be necessary.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916